

SONGS AND CALLS OF INDIAN BIRDS: IMPLICATIONS FOR BEHAVIOURAL STUDIES, SYSTEMATICS AND CONSERVATION

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This paper highlights the acoustical characteristics of the vocalizations of some Indian birds and their significance for behavioural, systematic, and conservation studies. The Indian birds investigated are known to use a varied range of species-specific vocalizations composed of simple, context-specific, monosyllabic, monotonous calls to highly varied, frequency modulated and complex songs. The frequency of most calls and songs ranged between 2 to 8 kHz. Non-passerine birds produced mostly simple vocalizations such as alarm, contact, flight, threat, territory and begging calls. Vocal repertoire of most passerines (songbirds) comprised songs and six to ten types of calls. Two categories of songs were mostly observed in bulbuls and robins. Type-A songs were discrete, composed of strophes or phrases preceded and followed by temporal intervals. These songs were simple, stereotyped, spontaneous, and common. Type-B songs were rare, female-oriented, and more complex. Song characteristics are highly diverse among Indian songbirds. The Common Tailorbird *Orlithotomus sutorius* and Black-throated Prinia *Prinia atrogularis*, produced simple repetitive songs, while the Red-billed Leiothrix *Leiothrix lutea* and Verditer Flycatcher *Eumyias thalassinus* produced complex, frequency modulated songs. Females of bulbuls and mynas sang quite frequently, while it was rare in some species (e.g. Oriental Magpie-Robin *Copsychus saularis*).

Key words: Indian birds, songs, calls, vocal repertoire, bioacoustics, animal behaviour

INTRODUCTION

Vocalizations are an important means of communication in birds and play a significant role in breeding, mating, sexual selection, cognition, cohesiveness, and foraging, and are thus essential for survival. Over the decades, these have been extensively used in science to address questions pertaining to animal behaviour, ecology, evolution and neurobiology. Vocalizations have been used to infer relationships, both within and between genera, and have been crucial in the discovery of many new avian species (Alstrom and Ranft 2003). Birds produce a wide range of context-specific simple to complex signals, which can be named as songs and calls (Catchpole and Slater 1995). Generally, songs are long, complex vocalizations, and in birds serve two major functions, i.e., the establishment and maintenance of territory, and mate acquisition (Catchpole and Slater 1995). Song characteristics, such as phonetics (acoustical features), syntax (mode of production), temporal pattern and structural complexity (variability of elements) are highly diverse among oscine birds (Marler and Slabbekoom 2004). In many species, repertoire is organised around a limited number of strophes or song types. In others, the song is composed of a large number of dissimilar structured song elements with an unrestricted number of combinations (Podos *et al.* 1992). The calls are often shorter, simpler, and monosyllabic, with simpler frequency patterns and produced by both sexes in various contexts.

The calls play an important role in the sociobiology of birds, namely social contact, parent-offspring interactions, cohesiveness among flock/family members, threat and danger. The repertoire of signals varies from species to species, sometimes quite small and sometimes unmanageably large. Relatively few have been intensively studied, and the entire repertoire has not often been thoroughly documented (Marler and Slabbekoom 2004). Though the importance of avian bioacoustic studies in behavioural ecology, sociobiology, evolutionary biology and neurobiology has been established globally and in India, yet scientific studies on their vocalizations are scanty (Kumar 2003). The present article highlights the general acoustical characteristics and biological significance of songs and calls of Indian birds, using some examples of Indian bird vocalization and available literature. Vocal repertoire of the Brahminy Starling *Temenuchus pagodarum* and song categories in White-eared Bulbul *Pycnonotus leucotis* have been carried out in detail.

METHODOLOGY

During April 1997 to June 2011, the songs and calls of over 200 species of birds were recorded at various locations, mostly in eastern and western Himalaya. Signals were recorded using Sony PCM-M1 or Marantz PMD222/PMD670 digital sound recorders and JVC MZ-500 or Sennheiser ME-66/Audio-Technica AT815b microphones and analysed using

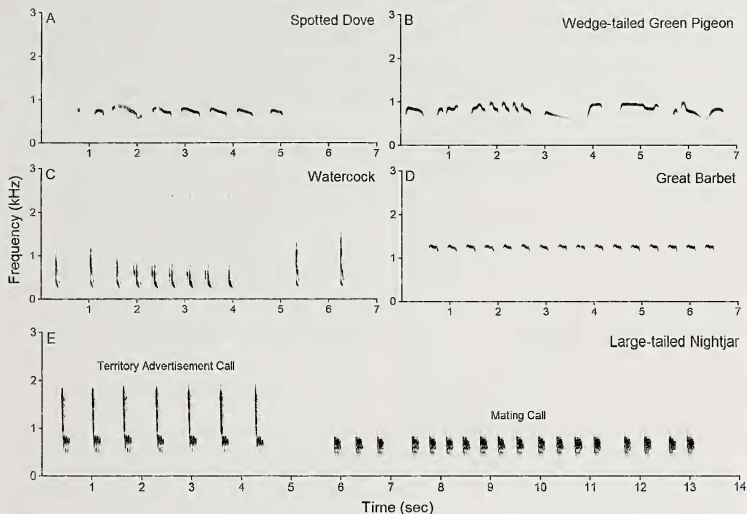


Fig. 1: Spectrograms of some vocalizations in non-passerine birds. (a) Territory advertisement calls of Spotted Dove, (b) Vocalizations of Wedge-tailed Green-Pigeon, (c) Territory advertisement calls of Spotted Dove, (d) Territory advertisement calls of Great Barbet, and (e) Two distinct categories of vocalizations in Large-tailed Nightjar

Avisoft SAS Lab Pro. Apart from recording the songs and calls in general, the vocal repertoire of some passerine species, Oriental Magpie-Robin *Copsychus saularis*, Indian Black Robin *Saxicoloides fulicatus*, Brahminy Starling *Temenuchus pagodarum*, Himalayan Bulbul *Pycnonotus leucogenys*, Red-vented Bulbul *Pycnonotus cafer*, and White-eared Bulbul *Pycnonotus leucotis*, were recorded in detail. Vocal repertoire of Brahminy Starling was documented based on the occasional recordings carried out on twelve individuals in northern India. Song categories in White-eared Bulbul were based on songs (N=8) recorded at Jodhpur during 2001. For bioacoustic analysis, spectrograms were displayed on a computer monitor and measurements of variables were made using frequency and time cursors. All spectrograms were calculated using following setting of SAS Lab: 512 FFT-length, 100% Frame, Flat Top window and 75 to 87.5% time window overlap. In some cases the temporal resolution was decreased or increased from 50% to

93.75%, as required. Software SPSS was used for statistical analysis.

RESULTS AND DISCUSSION

Bioacoustic analysis and interpretation of data reveals that most species used a varied range of context-specific vocalizations composed of simple, context-specific, monosyllabic, monotonous calls to highly varied, frequency modulated and complex songs. The frequency of most calls and songs ranged between 2 to 8 kHz.

Vocalizations of non-passerine birds: Non-passerine birds such as barbets, hornbills, kingfishers, cuckoos, owls, nightjars, doves, and pigeons were seen to produce mostly simple calls, often accompanied with visual displays for communication. Among these, male cuckoos, nightjars, and barbets used simple, loud, repetitive calls as a song resembling whistles, flutes or hiccups for territorial advertisement and sexual attraction. All species used signature

vocalizations, e.g., cuckoos used their own species-specific songs composed of discrete repetitive phrases, further made up of mostly simple, frequency modulated elements usually low frequency ranging from 0.5 to 3.5 kHz. Hornbills produced relatively low amplitude, short duration bark-like vocalizations. Pigeons and doves also produced continuous repetitive calls for territory advertisement (Figs 1a, b). Aquatic birds also produced contact calls and territorial calls, e.g., Watercock *Gallinix cinerea* used a wide-band resonating repetitive call (Fig. 1c).

Blue-throated Barbet *Megalaima asiatica* produced loud vocalizations in the breeding season (summer) from prominent positions on the upper canopy of tall trees. The vocalizations phonetically rendered as *poo...crooo...poo...crooo...* were composed of discrete phrases. The signal seems to be produced for territory advertisement and courtship. Great Barbet *Megalaima virens* also used loud, repetitive, monotonous *pio... pio...* calls for territory advertisement/courtship (Fig. 1d). Large-tailed Nightjar *Caprimulgus macrurus* produced loud resonating calls during the breeding season for territory advertisement (Fig. 1e). In the presence of a female, the male produced another type of call probably for mating purposes which seemed like a frog call rather than a bird call. In non-passerine birds, other categories of vocalizations were territory advertisement, alarm, contact, flight, and begging calls.

Studies on vocalizations of Indian non-passerine birds are limited to a few species (Ishtiaq and Rahmani 2005, Kumar and Sharma 2011). Overall, the investigations showed that non-passerines use a limited repertoire of vocalizations known as calls. These signals are innate and used for foraging, group cohesiveness, alarm, begging, and roosting, thus they are essential for survival. These are an ideal model to understand the ecology and evolution of acoustic communication of birds. However, the main focus of avian bioacoustic studies has been mainly on song and oscine birds, while non-passerine birds were often neglected. Thus, there is a gap in information that needs to be filled through research.

Vocalizations of passerine birds: Vocal repertoire of most of the songbirds studied comprised of song and six to ten types of calls, such as alarm (in some species two types), territorial, begging (in some species two or more than two types), roosting, emergence, contact, provisioning, mobbing, distress, greeting, and flight calls.

i. Vocal repertoire in Brahminy Starling

Bioacoustic analysis of the recordings of the Brahminy Starling revealed that it uses different types of vocalizations (Fig. 2, Table 1) for communication. On the basis of their physical characteristics, these signals can be classified into calls and songs.

a. *Alarm calls:* Based on the predation pressure and acoustical features, two distinct categories of alarm calls (i.e., type-1 and type-2) have been identified in this species. In the presence of predators such as sparrowhawk, crow, tree-pie, owl, rhesus macaque, and cat in the close vicinity of individuals or nest sites, the birds used type-1 calls. It was a harsh, wide band (frequency band width: 4.51 ± 0.185 kHz; $n=18$), stereotyped signal. Most individuals produced call notes (elements) with almost equal temporal gaps. The min., max., range, and dominant frequencies of these calls were 1.03 ± 0.023 , 5.56 ± 0.115 , 4.51 ± 0.185 and 7.78 ± 3.75 kHz, respectively. The average duration of elements was 0.637 ± 0.079 sec preceded and followed by average temporal gap of 1.35 ± 0.189 sec. During high predation pressure, especially when a predator approached close to the nest, type-2 calls were observed. These were monosyllabic, stereotyped, and low amplitude calls often with narrow descending frequency range. Results indicate that the type-1 calls were quite distinct from type-2 calls, both in physical characteristics (Table 1) and structure (Fig. 2).

b. *Distress calls:* Both, adults and juveniles were observed using these calls when captured by a predator or handled during mist-net capture. Since the physical characteristics of distress calls of adults and juveniles were similar, these were clumped for analysis. Nestlings and fledglings produced these calls during predator attacks or when handled for observations. These signals, phonetically rendered as *cheearr...chseerr...*, were composed of a wide range of frequencies. The min., max., range, and dominant frequencies of these calls were 0.85 ± 0.118 , 8.49 ± 0.324 , 7.62 ± 0.224 and 4.81 ± 0.731 kHz, respectively. The average duration of elements was 0.768 ± 0.034 sec, and the call interval was 1.89 ± 0.38 sec.

c. *Begging calls:* These vocalizations were produced by nestlings/fledglings. Three different types of calls were identified. On the basis of physical characteristics, these can be classified as type-I, type-II and type-III (Table 1, Fig. 2). Type-I calls were simple, stereotyped, wide-band without overtones, and composed of monosyllabic elements. The min., max., range, and dominant frequencies of these calls were 5.19 ± 0.085 , 8.36 ± 0.051 , 3.16 ± 0.042 , and 7.35 ± 0.164 kHz, respectively. The average duration of elements was 0.13 ± 0.002 sec and the call interval was 0.59 ± 0.062 sec. Type-II calls were monosyllabic with rapid frequency modulations, wide-band and without overtones. The min., max., range, and dominant frequencies of these calls were 0.98 ± 0.164 , 9.09 ± 0.096 , 8.02 ± 0.064 , and 4.48 ± 0.267 kHz, respectively. The average duration of elements was 0.071 ± 0.001 sec and the call interval was 0.876 ± 0.094 sec.

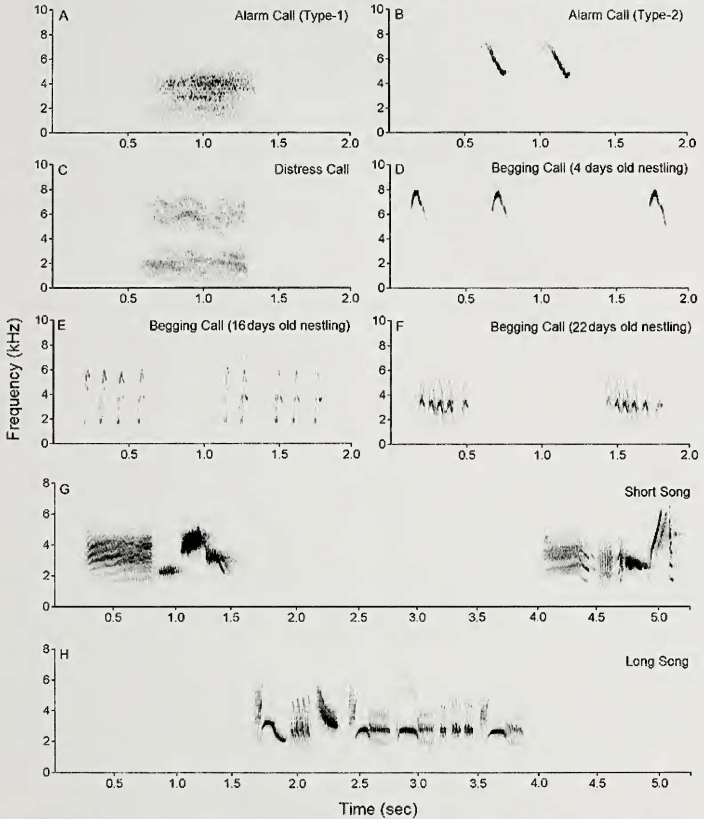


Fig. 2: Spectrograms of different types of calls and song in Brahminy Starling, (a) Alarm call type-1 used in low predation pressure, (b) Alarm call type-2 used in high predation pressure, (c) Distress calls, (d to f) Three different types of begging calls recorded in different age groups of nestlings, (g) Short song, and (h) Long song

Besides begging calls type-I and type-II, the nestlings were observed using another call. This call was observed only in the late nestling phase. It was composed of simple, monosyllabic, stereotyped wide band elements. The min., max.,

range, and dominant frequencies of these calls were 1.95 ± 0.078 , 6.115 ± 0.14 , 4.148 ± 0.14 , and 3.34 ± 0.037 kHz, respectively. The average duration of elements was 0.235 ± 0.012 sec and the gap was 1.9 ± 0.115 sec. The context of

production was also not clear. It seems that these calls are either the developmental phase of another vocalization or have a specific purpose – further investigations are needed.

Apart from the different types of calls, the Brahminy Starling used song for territory advertisement and/or mate acquisition. Adults produced song during the breeding season mostly in the morning (05:00-09:00 hrs) and evening (17:00-19:30 hrs). Individuals were observed singing from exposed branches of trees. The song of Brahminy Starling is discrete and composed of phrases. The min., max., range, and dominant frequencies of songs ($N=8$, $n=29$), were 1.42 ± 0.061 , 5.42 ± 0.156 , 4.00 ± 0.175 , and 3.00 ± 0.075 kHz respectively. Average duration of strophes was 0.95 ± 0.71 sec, preceded and followed by temporal gap 6.37 ± 0.072 ($n=29$) sec. Songs were produced at 8.91 ± 0.52 ($n=14$) strophes per min. The average number of elements/phrase and types of elements/phrase were 4.79 ± 0.32 and 4.24 ± 0.183 ($n=29$), respectively. In some cases, the song phrases comprised up to 11 elements sung at higher rate. It seems that Brahminy Starling uses two categories of song. The first category – ‘short songs’ – were for territory advertisement and second category – ‘long songs’ – were for mate acquisition. However, detailed investigations are needed to understand the proliferation of song in this species.

The vocalizations of only a few Indian species have been studied in detail; Oriental Magpie-Robin *Copsychus saularis* (Bhatt *et al.* 2000; Kumar and Bhatt 2001, 2002), Greenish Warbler *Phylloscopus trochiloides* (Katti 2001), Red-vented Bulbul *Pycnonotus cafer* (Kumar 2004), Brown Rock-chat *Cercomela fusca* (Sethi and Bhatt 2008), White-bellied Shortwing *Brachypteryx major* (Robin *et al.* 2011), Indian Black Robin *Saxicoloides fulicatus* (Kumar 2011) and Pied Bushchat *Saxicola caprata* (Sethi *et al.* 2012). These species used different types of context-specific vocalizations for communication. Some other species such as Common Chaffinch *Fringilla coelebs*, has eight basic calls (Bergmann 1993). Adult domestic fowl and Red Junglefowl (*Gallus gallus*) have a repertoire of up to about eighteen call types (Collias 1987). Snow (1958) estimates that adult Eurasian Blackbird *Turdus merula* has seven basic call types. Pied Flycatcher (*Ficedula hypoleuca*) and Collared Flycatcher (*Ficedula albicollis*) have been reported to use twelve call types (von Haartman and Lohrl 1950). There are similar estimates for the Great Tit *Parus major* and Black-capped Chickadee *Poecile atricapillus* (Hailman and Ficken 1996), and that of the Carolina Chickadee *Poecile carolinensis* seem to be somewhat larger (Smith 1972).

Review of literature revealed that most avian species produce specific alarm vocalizations when they encounter predators (Blumstein 1999). The alarm calls include several

categories of vocalizations based on the degree of predation pressure and location of predators (Ficken and Popp 1996). Some species produce a single invariant call, while others produce multiple types of calls because alarm calls convey specific information about environmental events (Blumstein 1999). Interactions between parents and nestlings/juveniles have been characterised by a number of calls, namely offspring call to get food, heat, and protection from predators, or parent call to provide offspring with information regarding food, predation pressure, and parent's location (Marler and Slabbekoom 2004). Distress calls are often produced when captured by a predator. Many birds produce roosting calls at their roosting sites.

ii. Complexity level of songs

Song characteristics are highly diverse among Indian songbirds. The Common Tailorbird *Orthotomus sutorius* and Hill Prinia *Prinia atrogularis* produced a simple song made up of one to three types of elements (Figs 3a, 3b); they repeat the same syllable. Grey-headed Canary-Flycatcher *Culicicapa ceylonensis* and White-throated Fantail *Rhipidura albicollis* used three to eight types of elements in their songs (Figs 3c, 3d), while thrushes, chats, babblers and pipits produced a wide range of complex songs. For example, Brown Rock-chat *Cercomela fusca*, Red-billed Leiothrix *Leiothrix lutea* and Verditer Flycatcher *Eumyias thalassinus* produced a wide range of frequency modulated, complex shaped elements in their songs (Figs 3e-g).

In most oscine birds, song complexity serves as an honest signal of male quality (Hesler *et al.* 2011), and selection may also favour song parameters, such as song rate and song length (Garamszegi and Møller 2004; Kunc *et al.* 2005). In species with large repertoire, sexual selection might favour the evolution of structural song traits, such as whistle songs in nightingales (Kunc *et al.* 2005), believed to have evolved to attract migrating females at night [as structurally simple whistles suffer less from spectral degradation during propagation over long distance (Slabbekoom *et al.* 2002)]. In species with a small repertoire, sexual selection may favour song length and song rate, as reported in some species such as Willow Tit *Parus montanus* (Welling *et al.* 1997), and Hoopoe *Upupa epops* (Martin-Vivaldi *et al.* 2002).

iii. Categories of songs

Two categories of songs were largely observed in the species of bulbuls and robins studied. However, based on this, it cannot be speculated that all Indian songbirds use two categories of songs. Species such as bulbuls sing throughout the year, while species such as robins, chats, pipits, and sunbirds sing only in the breeding season. The

Table 1: Physical characteristics of different types of calls in Brahminy Starling

Sr. No.	Physical Characteristics Types of calls	Produced by	Nature of call	Number of elements per call	Types of elements per call	Min. freq. (kHz)	Max. freq. (kHz)	Frequency Band width (kHz)	Dominant freq. (kHz)	Duration (sec)	Gap between elements (sec)
1.	Alarm Call (type-1)	Male and female under low predation pressure	Simple	1	1	1.03±0.023 (N=6, n=18)	5.56±0.115 (N=6, n=18)	4.51±0.185 (N=6, n=18)	7.78±3.75 (N=6, n=18)	0.637±0.079 (N=6, n=18)	1.35±0.189 (N=6, n=18)
2.	Alarm Call (type-2)	Male and female under high predation pressure	Simple	1	1	4.47±0.56 (N=6, n=18)	7.19±0.015 (N=6, n=18)	2.74±0.085 (N=6, n=18)	4.66±0.45 (N=6, n=18)	0.188±0.009 (N=6, n=18)	2.39±0.321 (N=6, n=18)
3.	Distress Call	Fledgling and adults	Simple	1	1	0.85±0.118 (N=2, n=6)	8.49±0.324 (N=2, n=6)	7.62±0.224 (N=2, n=6)	4.81±0.731 (N=2, n=6)	0.768±0.034 (N=2, n=6)	1.89±0.38 (N=2, n=6)
4.	Begging call (type-I)	Nestlings (mainly 3 to 8 days old)	Simple	1	1	5.19±0.085 (N=5, n=14)	8.36±0.051 (N=5, n=14)	3.16±0.042 (N=5, n=14)	7.35±0.164 (N=5, n=14)	0.13±0.002 (N=5, n=14)	0.59±0.082 (N=5, n=14)
5.	Begging call (type-II)	Nestlings (mainly 9 to 18 days old)	Simple	2-7	1	0.98±0.164 (N=5, n=14)	9.09±0.096 (N=5, n=14)	8.02±0.064 (N=5, n=14)	4.48±0.267 (N=5, n=14)	0.071±0.001 (N=5, n=14)	0.876±0.094 (N=5, n=14)
6.	Begging call (type-III)	Nestlings (19 to 24 days old) and fledglings (mainly during first one month after fledging)	Simple	2-7	1	1.95±0.078 (N=5, n=14)	6.115±0.14 (N=5, n=14)	4.148±0.14 (N=5, n=14)	3.34±0.037 (N=5, n=14)	0.235±0.012 (N=5, n=14)	1.9±0.115 (N=5, n=14)

N= number of individuals; n= total number of calls analyzed (2 to 3 calls per individual were analyzed)

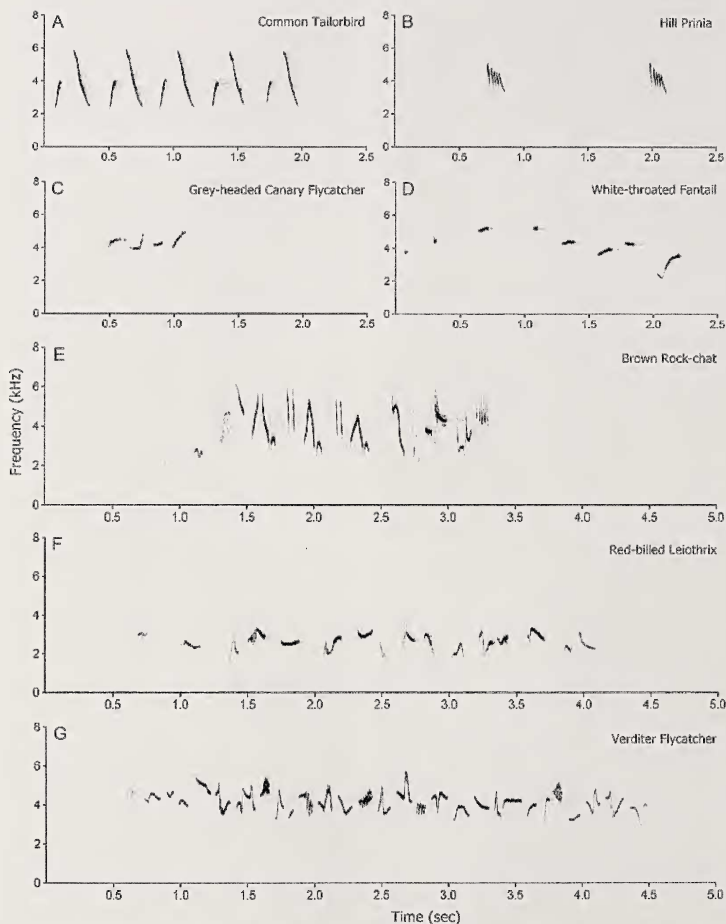


Fig. 3: Spectrograms of different types of songs. (a, b) Short and simple songs, (c, d) Medium songs usually made up of 3 to 6 types of elements per phrase, and (e to g) complex songs

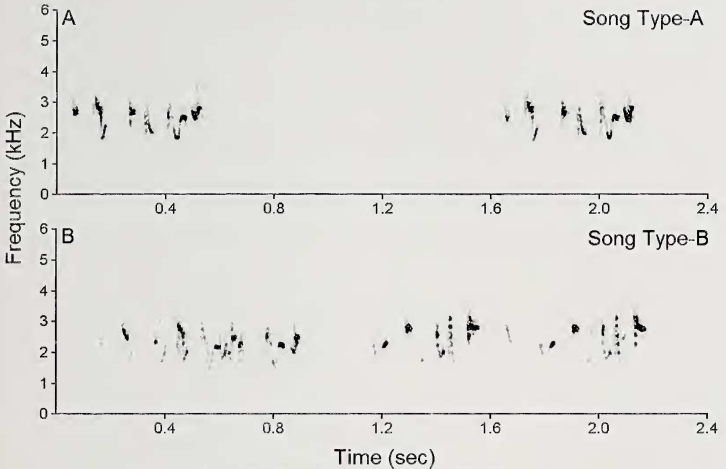


Fig. 4: Spectrograms of two categories of songs in White-eared Bulbul

White-eared Bulbul *Pycnonotus leucotis* sang throughout the year with increased singing bouts in the breeding season. Most of its songs (named Type-A) were discrete, made up of phrases (Fig. 4). The average min., max., range, and dominant frequencies of these vocalizations were 1.42 ± 0.043 , 4.26 ± 0.072 , 2.9 ± 0.08 , and 2.54 ± 0.035 kHz ($n=18$), respectively. The average duration of phrases was 0.576 ± 0.019 sec, preceded and followed by average temporal gap of 3.98 ± 0.429 sec ($n=18$). Most phrases were composed of elements ranging from 5 to 7 (average 5.77 ± 0.129 , $n=18$) elements per phrase, mostly dissimilar in structure. Occasional sharing and/or repetition of the elements were also observed. The rate of production was 8 to 12 phrases per min. The song was also used during foraging, greeting, and pre-roosting. Occasionally produced Type-B songs were also observed. These were about three to four times faster than Type-A songs (Fig. 4), however, the rate of overall production was low. Two to six phrases were produced with an irregular inter-phrase gaps. The gap between phrases and elements was lower than Type-A songs. These songs were observed always in the presence of another individual (most probably the female). However, sex in the present study could not be determined due to lack of sexual dimorphism in this species. It seems that these songs were for mate acquisition.

The Indian Black Robin *Saxicoloides fulicatus* (Family Muscipidae) produced mostly discrete songs, composed of strophes or phrases (structural units) preceded and followed by temporal intervals, known as Type-A songs. These songs were simple, stereotyped, spontaneous, and common. Sometimes individuals produced another category of songs known as Type-B songs. These were rare, female-oriented and more complex than Type-A (Kumar 2011). The Oriental Magpie-Robin *Copsychus saularis* also used two categories of songs, which were distinguished by their acoustical features and context of production. 'Discrete Songs' were common throughout the breeding period (March to July) and sung daily from prominent song posts by territory owner males. The males were observed singing 'Continuous Songs' in the presence of females (Kumar 1999). Bulbuls (Family Pycnonotidae) used Type-A songs (discrete, simple, loud, stereotyped, mostly spontaneous, and commonly sung throughout the year) to maintain pair bonds and Type-B songs (rare, complex, with irregular inter-phrase gaps with low amplitude and mate-oriented), for mating purposes. Song was used in both inter- and intra-sexual contexts (Kumar 2004).

Like Indian birds, some non-Indian passerines have been reported to sing two or more acoustically distinct song classes,

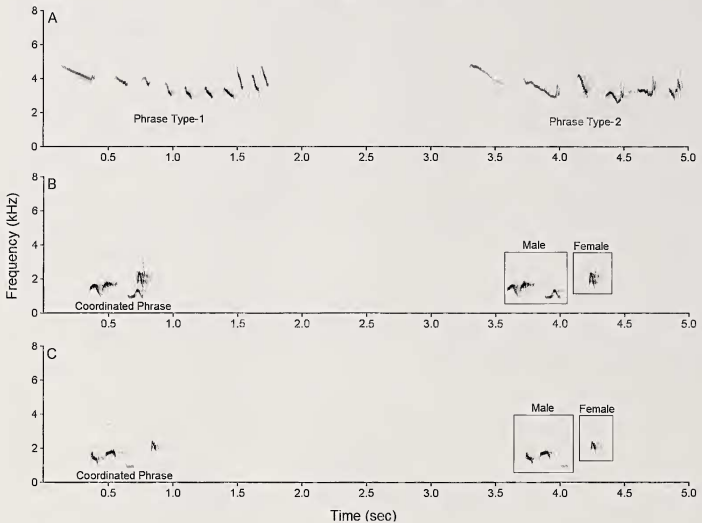


Fig. 5: Spectrograms of songs produced by females, (a) Solo song of female Oriental Magpie-Robin, (b) Duet song of Rusty-cheeked Scimitar-Babbler, and (c) Duet song of Spot-breasted Scimitar-Babbler

e.g., Dark-eyed Junco *Junco hyemalis* (Titus 1998), Field Sparrow *Spizella pusilla* (Nelson and Croner 1991), Yellow-throated Vireo *Vireo flavifrons* (Smith *et al.* 1978), Yellow-rumped Cacique *Cacicus cela* (Trainer 1987). In some other species, e.g., European Blackbird *Turdus merula* (Dabelsteen and Pedersen 1990), European Robin *Erithacus rubecula* (Dabelsteen *et al.* 1997), Common Whitethroat *Sylvia communis* (Balsby 2000) and Song Sparrow *Melospiza melodia* (Anderson *et al.* 2008), songs are described as 'broadcast songs' (like Type-A songs of Indian Robin) and 'soft songs' (such as Type-B songs of Indian Black Robin) also termed as 'quiet song', 'twitter song' or 'whisper song' in previous studies (Anderson *et al.* 2008). The first category songs of these species were loud and conspicuous, and second category songs were soft, low amplitude and rare, used in different contexts, such as courtship, male-male aggression or both (Anderson *et al.* 2008). However, in Indian Black Robin, Type-B songs were used only for mating/courtship (Kumar 2011). Some species of North American wood-warblers (Parulidae) also sing two categories of songs

(Spector 1992). The first category is often simple and highly stereotyped, sung at relatively low rates and near females, while the second category songs were usually more complex and variable, sung at higher rates and in male-male interactions (Bolsinger 2000). In contrast with the wood-warblers song system, Indian Black Robin used simple and stereotyped songs for territory/pair-bond maintenance and complex, varied songs for mating (Kumar 2011).

Some hypotheses have been postulated to explain the evolution of song categories in birds (Nelson and Croner 1991). It is hypothesised that all song types (phrases) within the vocal repertoire of a species may have the same purpose. Evolution of a large number of song types in a species may be favoured by both inter- and intra-sexual selection. Large repertoires may effectively repel rival males by appearing to represent the presence of several singing males. Large repertoires might also be favoured by females during mate selection (Catchpole 1980). Another hypothesis assumes that different song categories/song types within a repertoire contain different information (Trainer 1987). Different song

types are sung in different behavioural contexts, and thus appear to provide different information to listeners.

iv. Female participation in singing

In Indian birds, females in some species, such as bulbuls and mynas sing quite commonly, while it is a rare phenomenon in species such as Oriental Magpie-Robin. The female of this species sings occasionally (Kumar and Bhatt 2002). Solo and duet singing of Oriental Magpie-Robin was observed during this study: the duet song was without temporal coordination. Song features were similar to that of males. The song was short, simple, and discrete, composed of phrases made up of several elements which differ in acoustical characteristics and structure (Fig. 5a). The purpose of song seems to defend territory and to synchronize breeding. Some birds like scimitar-babblers produced well-coordinated duet song made up of phrases. In each phrase, the first two elements were produced by the male and the last by the female, such as in Rusty-cheeked Scimitar-Babbler *Pomatorhinus erythrogenys* and Spot-breasted Scimitar-Babbler *Pomatorhinus erythrocnemis* (Figs 5b, 5c).

Based on studies conducted on temperate birds, it was believed that songs are produced exclusively by males, with a few exceptions (Marler and Slabbekoorn 2004; Riebel 2003). Contrary to this, in the tropics, females also frequently sing either solo like males, or coordinated songs with males (Farabaugh 1982). A few hypotheses have been proposed to understand the differences between singing behaviour of females in tropics and tropical habitats (Slater and Mann 2004). Temperate and tropical birds experience different environmental pressures and life-history trajectories that may possibly account for the evolution of diverse behavioural patterns. Temperate zone species are often migratory, with short breeding seasons that create relatively brief periods of intense activity and distinct sex roles that may include major asymmetries in song production, reproductive behaviour, and territory defence. In contrast, many tropical species experience relatively little temporal environmental fluctuation, leading to sex role convergence, which may possibly favour female song, monogamy, shared territory defence and duetting (Morton 1996).

CONCLUSIONS

Vocalization is an important means of communication in birds and plays a vital role in their life cycle. Most birds

produce species-specific vocalizations, which can be used for species identification, description of new species, census and field survey. Discovery of new species, assessment of taxonomic rank and phylogenetic analysis is possible through vocalizations. Many new species have been identified due to their distinct vocalizations. Some morphologically similar species of birds can be easily separated by their vocalizations. Many wild species are elusive, hidden in impenetrable vegetation, or high in the canopy. Recording and playback are frequently used to attract individuals to the observer so that they may be identified visually, or to lure them towards traps/mist-nets. The relationship between songbirds and their habitat is reciprocal, and birds provide an excellent means to assess ecological changes. Birds usually occupy a diverse range of ecological niches and are sensitive bio-indicators. Conservation of songbird diversity can protect many other elements of biodiversity. Unfortunately, such studies on Indian birds are limited, while in Europe and America scientists are working for the last five decades, providing deep insights into the evolution of songs/calls in temperate birds. It is believed that most tropical birds exhibit social systems quite different from temperate species. Communication systems of most tropical Indian birds cannot be properly understood if studies are based on the information available on temperate birds. So, extensive long-term investigations are needed for the characterisation and documentation of the vocal repertoire of Indian birds.

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REFERENCES

- ALSTROM, P. & R. RANFT (2003): The use of sounds in avian systematics and the importance of bird sound archives. *Bull. B.O.C. 123A*: 114–135.
- ANDERSON, R.C., W.A. SEARCY, S. PETERS & S. NOWICKI (2008): Soft song in Song Sparrows: Acoustic structure and implications for signal function. *Ethology* 114: 662–676.
- BALSBY, T.J.S. (2000): The function of song in Lesser Whitethroats *Sylvia communis*. *Bioacoustics* 11: 17–30.
- BERGMANN, H.H. (1993): Der Buchfink. AULA-Verlag, Wiesbaden. Pp. 142.
- BHATT, D., A. KUMAR, Y. SINGH & R.B. PAYNE (2000): Territorial songs and calls in Oriental magpie robin *Copsychus saularis*. *Curr. Sci.* 78(6): 722–728.
- BLUMSTEIN, D.T. (1999): The evolution of functionally referential alarm communication: multiple adaptations; multiple constraints. *Evol. Comm.* 3: 135–147.
- BOLSINGER, J.S. (2000): Use of two song categories by Golden-cheeked Warblers. *Condor* 102: 539–552.
- CATCHPOLE, C.K. (1980): Sexual selection and the evolution of complex songs among European warblers of the genus *Acrocephalus*. *Behaviour* 74: 149–166.
- CATCHPOLE, C.K. & P.J.B. SLATER (1995): Bird song: Biological themes and variations. Cambridge University Press, UK. Pp. viii+248.
- COLLIAS, N.E. (1987): The vocal repertoire of the Red Junglefowl: A spectrographic classification and the code of communication. *Condor* 89: 510–524.
- DABELSTEEN, T. & S.B. PEDERSEN (1990): Song and information about aggressive responses of blackbirds *Turdus merula* – evidence from interactive playback experiments with territory owners. *Animal Behaviour* 40: 1158–1168.
- DABELSTEEN, T., P.K. MCGREGOR, J. HOLLAND, J.A. TOBIAS & S.B. PEDERSEN (1997): The signal function of overlapping singing in male robins. *Animal Behaviour* 53: 249–256.
- FARABAUGH, S.M. (1982): The ecological and social significance of duetting. Pp. 85–125. In: Kroodsma, D.E. and E.H. Miller (Eds): *Acoustic Communication in Birds*. Vol. 2. Academic Press, New York.
- FICKEN, M.S. & J. POPP (1996): A comparative analysis of passerine mobbing calls. *The Auk* 113(3): 370–380.
- GARAMSZEI, L.Z. & A.P. MÖLLER (2004): Extra pair paternity and evolution of bird song. *Behavioural Ecology* 15: 508–519.
- HAILMAN, J.P. & M.S. FICKEN (1996): Comparative analysis of vocal repertoires, with reference to chickadees. Pp. 136–159. In: Kroodsma, D.E. and E.H. Miller (Eds): *Ecology and Evolution of Acoustic Communication in Birds*. Cornell University Press, Ithaca, NY.
- HESLER, N., R. MUNDY & T. DABELSTEEN (2011): Does song repertoire size in Common Blackbirds play a role in an intra-sexual context? *Journal of Ornithology* 152(3): 370–401.
- ISHIAQ, F. & A.R. RAHMANI (2005): The Forest Owlet, *Heteroglaux blewitii*: vocalization, breeding biology and conservation. *Ibis* 147: 197–205.
- KATTI, M. (2001): Vocal communication and territoriality during the non-breeding season in a migrant warbler. *Curr. Sci.* 80(3): 419–423.
- KUMAR, ANIL (1999): Characteristics and significance of calls, songs and visual displays in two avian species viz. *Copsychus saularis* & *Pycnonotus cafer*. Ph.D. thesis, Gurukul Kangri University, Haridwar, India. Pp. 105.
- KUMAR, A. (2003): Acoustic communication in birds: Differences in songs and calls, their production and biological significance. *Resonance* 8(6): 44–55.
- KUMAR, A. (2004): Acoustic communication in the Red-vented bulbul *Pycnonotus cafer*. *An. Acad. Bras. Cienc.* 76(2): 350–358.
- KUMAR, A. (2011): Physical characteristics, categories and functions of song in Indian Robin *Saxicoloides fulicata* (Aves: Muscicapidae). *Journal of Threatened Taxa* 3(7): 1909–1918.
- KUMAR, A. & D. BHATT (2001): Characteristics and significance of calls in Oriental Magpie Robin. *Curr. Sci.* 80(1): 77–82.
- KUMAR, A. & D. BHATT (2002): Characteristics and significance of song in female Oriental magpie robin, *Copsychus saularis*. *J. Bombay Nat. Hist. Soc.* 99(1): 54–58.
- KUMAR, A. & R.K. SHARMA (2011): Observations on breeding behaviour and vocalizations in Red-wattled Lapwing, *Vanellus indicus* from northern India. *J. Exp. Zool. India* 14(1): 333–338.
- KUNC, H.P., V. AMREIN & M. NAGUIB (2005): Acoustic features of song categories and their possible implications for communication in the Common Nightingale (*Luscinia megarhynchos*). *Behaviour* 142: 1083–1097.
- MARLER, P. & H. SLABBEKOORN (2004): *Nature's Music: The Science of Birdsong*. Elsevier Academic Press, San Diego, California, USA. Pp. xvi+497.
- MARTIN-VIVALDI, M., J.G. MARTINEZ, J.J. PALOMINO & M. SOLER (2002): Extrapair paternity in the Hoopoe *Upupa epops*: an exploration of the influence of interactions between breeding pairs, non-pair males and strophe length. *Ibis* 144: 236–247.
- MORTON, E.S. (1996): A comparison of vocal behavior among tropical and temperate passerine birds. Pp. 258–268. In: Kroodsma, D.E. and E.H. Miller (Eds): *Ecology and Evolution of Acoustic Communication in Birds*. Cornell University Press, NY.
- NELSON, D.A. & L.J. CRONER (1991): Song categories and their functions in the Field Sparrow (*Spizella pusilla*). *Auk* 108: 42–52.
- PODOS, J., S. PETERS, T. RUDECKY, P. MARLER & S. NOWICKI (1992): The organization of song repertoires in song sparrows: themes and variations. *Ethology* 90: 89–106.
- RIEBEL, K. (2003): The 'mute' sex revisited: vocal production and perception learning in female songbirds. *Adv. Study Behav.* 33: 49–86.
- ROBIN, V.V., M. KATTI, C. PURUSHOTHAM, A. SANCHETI & A. SINHA (2011): Singing in the sky: song variation in an endemic bird on the sky islands of southern India. *Animal Behaviour* 82: 513–520.
- SETHI, V.K. & D. BHATT (2008): Call repertoire of an endemic avian species, the Indian chat *Cercomela fusca*. *Curr. Sci.* 94(9): 1173–1179.
- SETHI, V.K., D. BHATT & AMIT KUMAR (2012): Characteristics and behavioural correlates of call types in a tropical bird, the Pied Bushchat *Saxicola caprata*. *Pakistan J. Zool.* 44(5): 1231–1238.
- SLABBEKOORN, H., J. ELLERS & T.B. SMITH (2002): Birdsong and sound transmission: The benefits of reverberations. *Condor* 104: 564–573.
- SLATER, P.J.B. & N.I. MANN (2004): Why do the females of many bird species sing in the tropics? *J. Avian Biol.* 35: 289–294.
- SMITH, S.T. (1972): Communication and other social behavior in *Parus carolinensis*. *Nuttall Ornithological Club* 11: 1–125.
- SMITH, W.J., J. PAWLKIEWICZ & S.T. SMITH (1978): Kinds of activities correlated with singing patterns of the Yellow-throated Vireo. *Animal Behaviour* 26: 862–885.
- SNOW, D.W. (1958): *A study of Blackbirds*. Allen and Unwin, London. Pp. 192.
- SPECTOR, D.A. (1992): Wood-warbler song systems. A review of paruline singing behaviours. Pp. 199–238. In: Power, M.D. (Ed.): *Current Ornithology*. Plenum Press, New York. Pp. 238.
- TITUS, R.C. (1998): Short-range and long-range songs: Use of two acoustically distinct song classes by Dark-eyed Juncos. *Auk* 115(2): 386–393.

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- TRAINER, J.M. (1987): Behavioural associations of song types during aggressive interactions among male Yellow-rumped Caciques. *Condor* 89: 731-738.
- VON HAARTMANN, L. & H. LOHRL (1950): Die Lautausserungen des Trauer- und Halsband-fliegenschnappers, *Muscicapa h.*

- hypoleuca* (Pall.) und *M. a. albicollis* Temminck. *Ornis Fennica* 27: 85-97.
- WELLING, P.P., S.O. RYTKONEN, K.T. KOIVULA & M.I. ORELL (1997): Song rate correlates with parental care and survival in willow tits: advertisement of male quality? *Behaviour* 134: 891-904.

